External Forces on the Work System: A Framework for Human Factors Implications

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Abstract

Human factors/ergonomics only occasionally addresses its own future, but business and political forces are changing so rapidly that we must do so now. Globalization of business, made possible by information technology and political desire, is affecting many aspects of our profession, from increased work pace to re-location of jobs. These changes in turn impact human factors issues as diverse as errors in human computer interaction and the incidence of musculo-skeletal disorders. This paper presents a framework for considering the impact of these changes on the practice of human factors/ergonomics so that we may plan for the future rather than be overwhelmed by it.

1. Interaction: The Future and Ergonomics.

This paper examines the interface between the global forces acting on human work and the fields within human factors/ ergonomics which must ultimately adapt to these changes. If interfaces are the *raison d'etre* of ergonomics (Wilson, 1999), then the interface between our discipline and the world's changes must rank high on our list of concerns. We must start with the external global forces, because these will be there no matter what our response. Next, we consider the adaptations that may be required in a number of our sub-fields as a concrete path towards a more general response framework. In any paper of this length, we must deal only with the highest level of interaction, leaving for the future the task of a comprehensive consideration of these interactions.

2. Where is work going?

My contention is that the gradual globalization of commerce over the past decades represents a major factor impacting the organizations for which we work. There are many other issues of importance, such as information technology, the spread of electronic commerce and environmental carrying capacity, but these can be seen as aspects of globalization. Perhaps the only major issue that is not a part of globalization is the changing nature of the workforce. Even here, at least some of the issues are a result of the forces of globalization where disadvantaged immigrants seek better lives in developed nations, as indeed they always have.

Globalization is the combination of market and political forces that have reshaped business and politics since the end of the cold war in the late 1980's. Some of these forces, such as technological change, are obvious to those who study work, but other forces are changing the nature of jobs, perhaps even more profoundly. Globalization of customers, finance and production of goods and services has been driven by forces of deregulation, inexpensive transportation and rapid diffusion of distributed computing (Friedman, 1999). Industry is becoming spread across more regions of the world, is shifting towards communications and service, and global capital markets force "creative destruction", i.e. the often brutal flow of capital away from enterprises with low shareholder value to enterprises where the capital will generate the greatest return. Investment moves rapidly, forcing industries to respond equally quickly to changing customer demands. We have moved from managerial capitalism of the first part of this century to investor capitalism with more demanding shareholders (e.g. large pension funds) and more information available instantly (Whitman, 1999). Even national governments are being forced by the instantaneous investment community to reduce their costs and become more open and transparent, what Friedman calls the "golden straightjacket". Kanter (1995, 1999) characterizes these changes as greater Mobility (of capital, people, ideas), greater Simultaneity (of technology or investment information) greater Bypass (other choices besides large corporations) and greater Pluralism (with smaller headquarters and decentralized decision making). She advocates that industry "think like a customer".

While these changes may seem remote from the lives of human factors professionals, they in fact have very direct effects as they are driving industry into new modes of operation beyond technological changes. Specifically:

1. Most workers will be more closely involved with customers, as consumers are increasingly demanding a combination of high quality, customization and low price (Whitman, 1999). Exposing the workforce to customers will change the skill requirements of jobs to include communications skills, as has always been the case in service industries such as travel and banking. Customer

involvement can increase job satisfaction but also can increase performance pressure.

2. Many operations will be outsourced, leading to reduced levels of job security and more temporary jobs (Whitman, 1999; Budros, 1999). In fact layoffs in US industry peaked in 1992-1995 at a time of maximum job growth. The fastest growing category was in temporary jobs, which rose six-fold between 1972 and 1995 (Whitman, 1999). The total number of temporary jobs is still small, but is a major concern of workers (Kanter 1995, Chapter 6).

3. Workers are increasingly divided into "mobiles" with internationally-useful skills, and "non-mobiles" who stay in one location and have to accept scarce low-skilled jobs (Kanter, 1999).

4. More jobs are being created in small to medium enterprises (SMEs) than in large companies (Budros, 1999), although the major employment sector is still businesses employing over 500 people, accounting for 41% of all employment (Rifkin, 1995). SMEs can mean more workers without the benefit of extensive services, such as on-site medical or ergonomics programs. It also means less unionization, down from 33% in 1955 to 16% in 1995 in the USA (Whitman, 1999)

5. Global standards are being adopted by multi-national businesses as they try to ensure that they are always ready for future changes. Although many companies still use differences in standards between countries to reduce business costs, more progressive companies are using the most stringent world standards as the basis for their global operations (Kanter, 1999). One effect of this is that standards set by a single country may be less relevant to increasingly-global enterprises unless they happen to be the most stringent. An obvious example is the ISO-9000 series of quality standards which have had a great leveling effect across different nations (Kroslid, 1999).

These industry changes are pushing job change. A new regionalism is spreading, with specific regions specializing as thinkers (e.g. Silicon Valley, Bangalore), makers (e.g. Cleveland, Southern California) or traders (e.g. Miami, Singapore, Hong Kong). Job loss is occurring in industries not involved with global competition, and in areas where infrastructure (including labor costs) are not optimum. For industrial workers, major overall results are job loss in developed economies, temporary jobs, longer hours of work, more people with two jobs, and sub-contract jobs instead of regular employment (Rifkin, 1995). Global competition has forced many companies to downsize their workforce to remain competitive and increase shareholder value. Budros (1999) examines the reasons for downsizing, as separate from reorganization. He sees the downsizing trend as being caused by technological innovation and by the existence of highly-paid long-term employees. He also sees less desirable reasons for the practice, ranging from CEO's coming from primarily financial rather than production backgrounds, and even following of fashion. He concludes that downsizing is not always effective. From a work perspective, downsizing can be expected to increase workloads for those remaining, and to remove some of the company expertise, leading to potential for increased error and injury rates. Work hour overall may be increasing for Americans according to Schor (1991). She analyses national data on long-term employment hours of work, vacation time, and work in the home, concluding that total hours of work have increased by about one month per year over the past 40 years or so. While her data and analyses have been questioned, we seem to find very few people who are not working harder than they used to.

Global changes are also driving job demands in ways beyond employment security. Increasingly, work at the world-class levels demanded by global competition generate greater worker skill requirements and greater rate of worker knowledge obsolescence. Kanter (1999) shows that even in manufacturing, physical assets represented 63% of company capitalization in 1982, but only 38% in 1991. The remainder of the assets are largely composed of company knowledge and competence. Indeed, Siemieniuch and Sinclair (1999) show that even if useful industrial knowledge has a half-life as long as 10 years, only 6% of the knowledge at the start of a working life will be useful at the end 40 years later. When we retire, we will be producing unknowable offerings (goods and services) with unborn people and uninvented techniques. In turn, this creates a demand for life-long training. Whitman (1999) notes that companies with a heavy emphasis on training show a 19% greater productivity gain over a 3 year interval than other companies.

There are other industrial changes taking place at the same time, not specifically part of the globalization of work. Information technology is becoming a part of ALL jobs as computing power becomes less expensive and more distributed. We not only use information technology to replace workers, but to change the nature of their jobs. While only a few years ago, the National Research Council was investigating the gap between IT investment and productivity improvement (NRC 1999), it now appears that the gap has closed and that computing power is having a significant effect on both productivity growth and the nature of work.

New forms of organization based on socio-technical systems (STS) concepts are being introduced into many industries, service as well as manufacturing (Taylor and Felten, 1993). These involve a more complete systems analysis than is typical in many business change practices such as Business Process Reengineering (Hammer and Champey, 1990). Note that modern business practices appear not to be differentially employed by companies of different sizes and in different sectors (Waterson, 1999). STS also specifically involves the whole workforce in analyzing both the technical system (to find the key variances in the process) and the social system (to find how

these variances are controlled). Such reorganizations have been effective in a number of industries, and should reduce MDS risk exposure by active design of jobs, rather than assigning to human operators the tasks left over from a mainly automated system (Bainbridge, 1983). Batt (1999) measured the effects of STS as well as Total Quality Management (TQM) approaches to customer service representatives in a typical service industry and concluded that only the STS redesign had a large and positive effect on both quality and productivity. Her work ended sadly when the company killed both STS and TQM programs and reverted to a system that emphasized performance speed only.

3. Selected Human Factors Impacts

In this section, four sub-specialties within ergonomics/human factors are examined to predict some likely impacts of these external forces. The four areas are chosen without any data on their global impact, and the interactions noted are only ones obvious to the author. For these reasons, the final section examines a more comprehensive framework for evaluating the impact of change on our discipline.

Perhaps the most obvious impact is an human/computer interaction (HCI). As the computer comes to a position of mediating more and more human activities, there is a clear need to devise appropriate computer interfaces for the humans in the system. But the IT changes themselves will embed the computers into other devices, meaning that HCI will become more a matter of humans interacting with their more intelligent tools. Global communications mean that intelligent tools will appear around the world almost simultaneously and with greater openness. Also, as we move towards the service economy (Chen and Drury, 1999), then our human operator must be in much closer linkage with the customer, rather than isolated in a factory or office. Implications for human factors are not hard to imagine. The service dimension implies training and software support for social skills as well as domain knowledge. The ubiquity of computers implies interface standards across a variety of human artifacts if we are not to be plagued by mode errors. Our interfaces for interaction with an intelligent VCR or refrigerator should not conflict with responses required for an ATM or even a chain saw. Clearly, better designs of keyboards and mice as not going to solve these HCI problems, but a deeper understanding of human interaction with automation will be needed.

A second exemplar area is in human injury prevention, particularly for musculo-skeletal disorders. Some progress has already been made in considering the impact of global forces on this problem (Mavor and Drury, 2000). Factors such as increased hours of work and greater reliance on distribution centers for electronic commerce suggest that exposure to MSD risk factors may increase rather than decrease in our more automated global economy. As product manufacturer moves from developed to developing countries, the repetitive tasks that are precursors of MSD may be performed by people with less resource for heath and safety standards, or even union representation, in these countries. On the other hand, as industry moves towards more global standards and socio-technical systems design of jobs may decrease health threats from MSDs.

4. A Framework for Assessing Impacts

We are faced with far more than just two aspects of human factors/ergonomics, all being impacted by the multiple facets of globalization noted in Section 2. To assess the possible interactions in an orderly manner we clearly need more than arbitrarily chosen exemplars.

The first requirements is for a framework for enumerating and assessing the interaction between factors molding the future of work and our own human factors/ ergonomics concerns. One such framework is a matrix with future drivers as the rows and ergonomics issues as the columns. Table 1 shows the first part of such a matrix, based on the considerations listed in this paper. In this table the discussions of Section 3 become cell entries which need to be assessed and ultimately addressed by the profession. Thus, the musculo-skeletal disorder interactions noted above become entries in three cells of this table, while the HCI issues fill in further cells.

Clearly, this paper only provides a framework and a few cell entries for our future impact matrix. Much work will be required to fill out this matrix with possible impacts and potential actions based on these impacts. Such an approach has already been advocated for examining in detail the future trends for MSD's (Mavor and Drury, 2000) and as a technique for broadening the potential impact of human factor on organization's operations (Gramopadhye and Drury, 1999). It is offered here as a way to help us all become less reactive to externally-imposed demands, and to structure our future to better match the future we can see approaching rapidly in the new century.

What are the next steps? First, we must fill in more rows as we see more global trends rushing to meet us. Two examples would be the changing nature of the workforce, and the need for economies that are sustainable in the long term. For these we need to broaden our view far beyond our discipline and integrate the social, economic and political currents of our time into our worldview. Second, we must fill in more matrix columns to cover our sub-disciplines. Here we have reasonable taxonomies of ergonomics, ranging from rather crude (e.g. the list of HFES technical groups) to highly detailed (e.g. the *Ergonomics Abstracts* topic classification or one of the emerging encyclopedias of ergonomics). Rows and columns will probably be best characterized as hierarchical structures rather than simple lists.

Filling in the cells of our matrix will have to be a combination of extrapolation from our past and logical

consideration of interactions. Here we can find help from the many publications on the future of work, for example, Howard (1995); National Research Council (1999). But the real effort will be to turn these potential interactions into prescriptions for action. A major characteristic of the new global economy is that it rewards initiative, but objects to paying for the long-term view which can produce that initiative. We may have to rely on sources of voluntary work rather than expect organizations driven by shareholder capitalism to fund our preparation for the future.

References

Bainbridge, L. (1983). Ironies of Automation. *Automatica*, **19(6)**, 775-779.

Batt, R. (1999). Work Organization, Technology, and Performance in Customer Service and Sales. *Industrial and Labor Relations*, **52.4**, 532-564.

Budros, A. (1999). A conceptual Framework for Analyzing why Organizations Downsize, *Organizational Science*, **10.1**, 69-82.

Chen, A.-J. and Drury, C. G. (1999). Human errors and customer service quality. *Proc. Intl Conference on TQM and Human Factors-- towards successful integration*, Linkoping, Sweden: Linkoping University and Institute of Technology, 76-81.

Friedman, T. L. (1999). *The Lexus and the Olive Tree: Understanding Globalization, Farrar, Straus and Giroux*, NY.

Gramopadhye, A. and Drury, C.G. (1999). Editorial – Human factors in aviation maintenance: how we got to where we are, *Intl Journal of Industrial Engineering.*

Hammer, M. and Champy, J. (1993). *Reengineering The Corporation.* New York: Harper Business.

Howard, A. (Ed.) (1995). *The Changing Nature of Work.* San Francisco, CA: Jossey-Bass Publishers.

Kanter, E. M. (1995) *World Class: Thriving Locally in the Global Economy*, NY: Simon & Schuster.

Kanter, E. M. (1999). Challenges in the global economy, *The Washington Quarterly*, **22.2**, 39-58.

Kroslid, D. (1999). In Search of Quality Management – rethinking and reinterpreting. Unpublished Ph.D. Thesis, Linkoping Institute of Technology, Sweden.

Mavor, A. and Drury, C. G. (2000). *The Future of Work: Implications for Musculoskeletal Disorders,* National Research Council, Wash, D.C.: National Acad. Press.

National Research Council. (1999). *The Changing Nature of Work: Implications for Occupational Analysis.* Committee on Techniques for the Enhancement of Human Performance: the National Research Council. Washington, DC: National Academy Press.

Rifkin, J. (1995). *The End of Work*, Putnam, NY.

Schor, J. B. (1991). *The Overworked American*, Basic Books, NY.

Siemieniuch, C. E. and Sinclair, M. A. (1999). Knowledge Lifecycle Management in Manufacturing Organizations, 1999. In M. A. Hanson, E. J. Lovesey and S. A. Robertson (Eds.), *Contemporary Ergonomics,* London, UK: Taylor & Francis, 322-332.

Waterson, P. E. et al (1999) The use and effectiveness of modern manufacturing practices: a survey of UK industry, *IJPR*, **37.10**, 2271-2292.

Wilson, J. (1999). Interactions as the focus for human centred systems. Keynote address, *Proc Intl Conference on TQM and Human Factors-- towards successful integration*, (Linkoping, Sweden: Linkoping University and Institute of Technology).

Whitman, M. vN. (1999). Global Competition and the Changing Role of the American Corporation, *The Washington Quarterly,* **22.2**, 59-82.

	Human Factors Issues		
Forces Shaping Work	**HCI**	**MSD**	**Etc.**
Customer involvement	X		.....
Outsourcing/downsizing		X	
Mobiles/non-mobiles			
Global standards	X	X	
Regionalism			
Embedded IT	X		
New organization design		X	
Electronic commerce		X	
....			
Etc.			....

Table 1. Incomplete interaction matrix as a framework for assessing the impact of business forces on human factors/ergonomics. X represents an interaction discussed in Section 3.